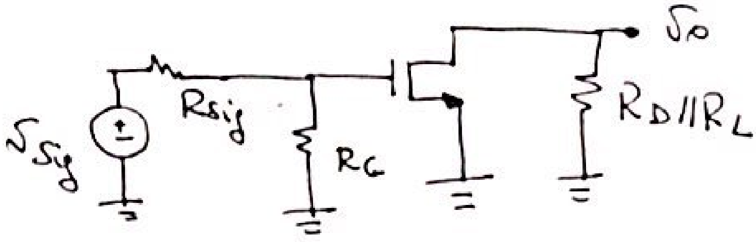
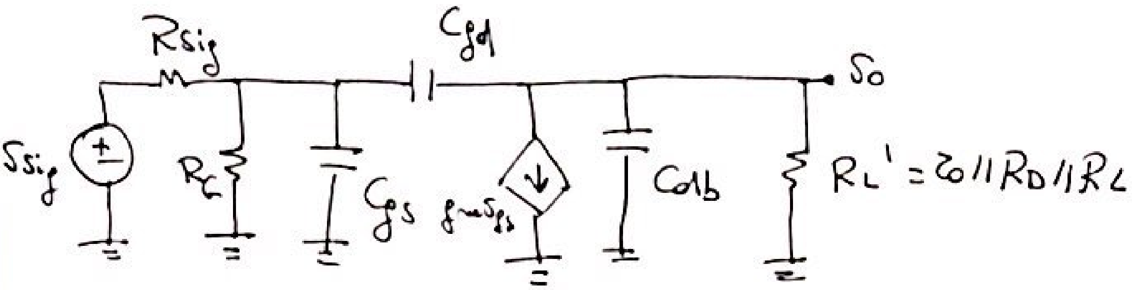
In class problem - Lecture 19

AC - CIRCUIT AT HIGH FREQUENCY

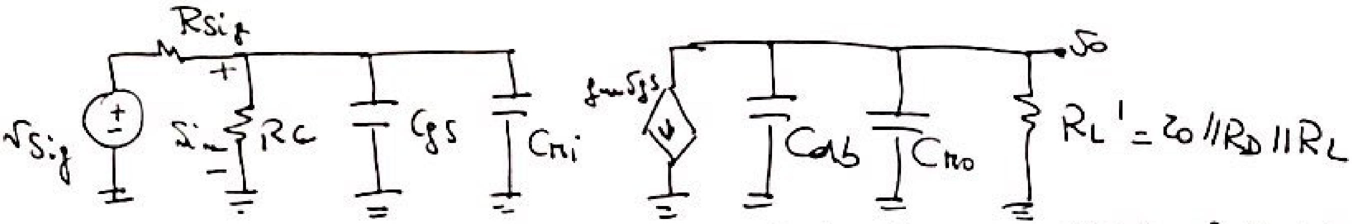


The circuit is obtained by replacing coupling and bypass capacitors with short-circuits.

Small signal equivalent circuit at high frequency



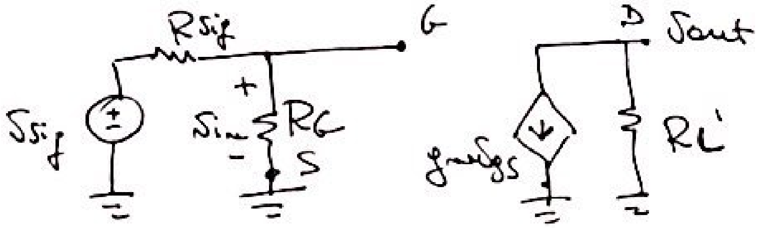
C_{gd} is a capacitor between the input and the output. We can use the Miller's theorem to simplify the circuit.



We have 2 capacitors: $C_{in} = C_{gs} + C_{Mi}$ and $C_{out} = C_{db} + C_{Mo}$ yielding 2 upper corner freq.

$$C_{Mi} = C_{gd}(1 - A_V) \qquad C_{Mo} = C_{gd}\left(1 - \frac{1}{A_V}\right) \qquad A_V = \frac{v_o}{v_{in}}$$

To calculate the midband gain we need to use the circuit below:



This midband circuit can be obtained from the high-frequency small-signal circuit by replacing the FET capacitors with open circuits.

$$A_V = \frac{v_o}{v_{in}} \qquad v_o = -g_m v_{gs} R_L'$$

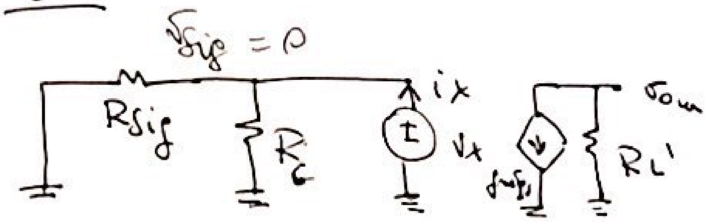
$$v_{gs} = v_{in} \Rightarrow A_V = -g_m R_L'$$

Thus $C_{Hi} = C_{gd}(1 + g_m R_L')$ and $C_{Ho} = C_{gd}\left(1 + \frac{1}{g_m R_L'}\right)$

The two upper corner frequencies to be determined are

$$f_{Hi} = \frac{1}{2\pi\,(C_{gs} + C_{Hi})\,(R_{eq\,i})} \qquad f_{Ho} = \frac{1}{2\pi\,(C_{db} + C_{Ho})\,(R_{eq\,o})}$$

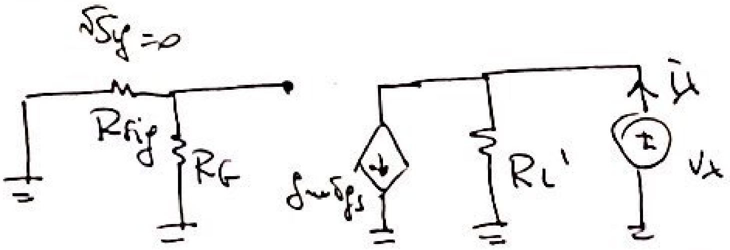
$\underline{f_{Hi}}$



$$R_{eq\,i} = \frac{v_x}{i_x} = R_{sig} \parallel R_G$$

$$\boxed{f_{Hi} = \frac{1}{2\pi\left[C_{gs} + C_{gd}(1 + g_m R_L')\right](R_{sig} \parallel R_G)}}$$

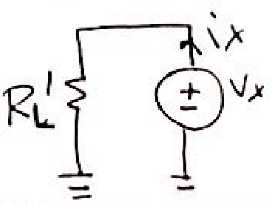
$\underline{f_{Ho}}$



$$R_{eq\,o} = \frac{v_x}{i_x}$$

$v_{gs} = 0 \Rightarrow g_m v_{gs} = 0$

Thus



$$R_{eq\,o} = R_L'$$

$$\boxed{f_{Ho} = \frac{1}{2\pi\left[C_{db} + C_{gd}\left(1 + \frac{1}{g_m R_L'}\right)\right] \cdot R_L'}}$$